DEC STD 070-12 Video Systems Reference Manual - Terminal Synchronization

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ABSTRACT: This standard applies to serial asynchronous communications which use XON/XOFF flow control or Break for synchronization. It describes the XON/XOFF flow control protocol including response time and input buffer requirements. It also specifies requirements for implementing the Break function in terminals. This standard supersedes DEC STD 111-0 Terminal Synchronization.

APPLICABILITY: Mandatory for Engineers designing hardware for terminal products and Software Engineers designing programs using terminal interfaces. Additional requirements are defined in DEC STD 070-1 Concepts and Conformance Criteria.

STATUS: APPROVED 26-Jul-1990; use VTX SMC for current status.

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1 INTRODUCTION

This document describes synchronization mechanisms for software which interfaces computers to terminal devices. These mechanisms are used for flow control to prevent devices from losing data received faster than it can be processed; to synchronize keyboard and display processing in terminals with software running on remote hosts; and to reset or initialize the communications context. Currently these mechanisms are defined for use over serial asynchronous communications lines, and include XON/XOFF flow control and Break.

XON/XOFF flow control is a means of using control characters DC1 (XON) and DC3 (XOFF) to alternately suspend and resume the flow of characters over serial asynchronous communication lines.

Break is an out of band signal frequently used to reset the communications environment or data interchange context over serial asynchronous lines. The Break condition is defined as a continuous space (transmission line held in its zero state) for longer than one character time. Although there is no standard use for Break, Digital terminals allow the Break signal to be generated under user control.

1.1 SCOPE

This standard applies to all Digital products which implement XON/XOFF flow control, all products which are intended to be certified as conforming to the Terminal Interface Architecture, and software which is intended to use terminal interfaces in a conforming manner.

1.2 RELATIONSHIP TO TIA

XON/XOFF flow control and break are part of the external communications interface that lies below the code extension layer. Flow control and break are management functions that control the communications link. No conforming applications should depend on the presence of, or performance characteristics of terminal synchronization.

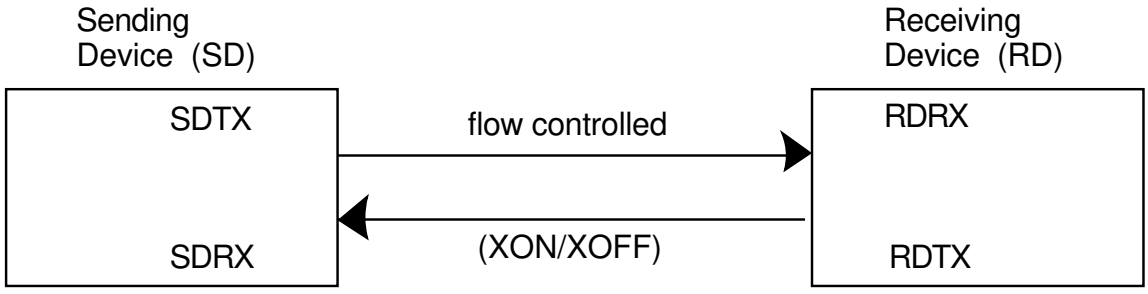
2 XON/XOFF FLOW CONTROL

2.1 PROTOCOL

XON/XOFF flow control is a means of using C0 control characters DC1 (1/1) (XON) and DC3 (1/3) (XOFF) to alternately suspend and resume the flow of characters over serial asynchronous point to point communication lines. Flow control is used to avoid losing data when a sending device is capable of transmitting data faster than the corresponding receiving device can process or use it.

XON/XOFF flow control is only applicable to full duplex communication lines with a specified minimum amount of receive data buffering. The exact buffer requirements depend on the maximum transmission rate and response time of the sender and receiver.

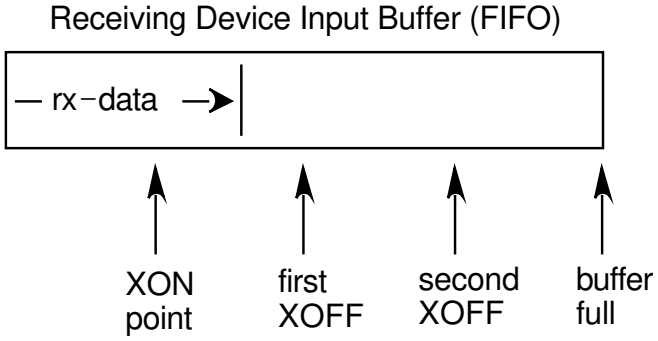
XON/XOFF flow control is a symmetric protocol and may be used independently in either or both directions. Only one direction is described below for simplicity. Most systems will conform as both a sending device and a receiving device. Product documentation should state clearly if an implementation intends to only conform as a sending device or receiving device.



When XON/XOFF flow control is enabled between a sending device and a receiving device, XON and XOFF characters received at the sending device (SDRX) are interpreted as flow control and are not stored in the sending device's input buffer. Because they are used for flow control, characters XON and XOFF may not be passed as part of the normal data interchange from the receiving device to the sending device.

The sending device recognizes XOFF (1/3) as a request from the receiving device to suspend the transmission of characters. When this character is received by the sending device, transmission of all characters (other than XON or XOFF) to the receiving device is suspended. When the sending device's communication port is in this state, it is said to be in the XOFF state. If the device is already in the XOFF state when an XOFF character is received, this character is ignored.

The sending device recognizes XON (1/1) as permission from the receiving device to resume the transmission of characters, if any. When this character is received by the sending device, the XOFF state of the device's communication port is cleared and transmission of characters in the communication port output buffer is resumed. If the device was not XOFF-ed, this character is ignored.



The receiving device transmits XOFF to the sending device if a character other than XON or XOFF that would be stored in the input buffer is received from that device, and (1) the number of characters in the input buffer reaches the first XOFF point for the first time since the last XON was sent; (2) the number of characters in the input buffer reaches the second XOFF point for the first time since the last XON was sent; or (3) the input buffer is full. If the input buffer is full, the received character is discarded. An error indication

should be made in the receiving device if characters are discarded (not mandatory). A terminal might display the error character for example.

If the sending device can respond to XOFF fast enough to avoid buffer overflow from the second XOFF point, reliability is improved on systems where the first XOFF might be lost during transmission. Support for the second XOFF point is not mandatory, but recommended for use over noisy communication channels.

The reason to send an XOFF for each character that arrives while the input buffer is full is to insure that the sending device will receive an XOFF even if it is reset (clearing the XOFF state) after the input buffer was filled. Transmission of XOFF for each character received while the input buffer is full is not mandatory.

The receiving device transmits an XON to the sending device when the receiving device's input buffer empties to the XON point, and the last flow control sent by the receiving device was XOFF. This XON must not be blocked by any data being held in the receiving device's transmit queue. If both devices had transmit queues and did not allow XON characters to bypass them, they could become locked in a "deadly embrace". Special provision shall be made to send XON promptly regardless of the XON/XOFF state of the receiving device.

2.2 XON AND XOFF POINTS

2.2.1 Requirements

The choice of XON and XOFF points will depend on the receive buffer size and the performance characteristics desired. The following requirements apply to the selection of XON and XOFF points. In all cases, the first XOFF point must be higher (closer to buffer full) than the XON point.

Terminals shall provide at least 32 characters of receive buffer space beyond each XOFF point supported (the buffer full condition is not considered an XOFF point).

When an XOFF point is reached, the receiving device should transmit XOFF as soon as possible to maximize the response time available to the sender. It is anticipated that some hardware devices will employ a transmit output buffer and will not be able to insert XOFF into the output stream immediately. In the worst case, XOFF shall be transmitted within five character times from when the XOFF point was reached.

Some implementations allow the first XOFF point to be selected under local control to limit the number of characters ahead of the screen the host can transmit. For interactive terminals with large input buffers, it shall be possible to set the first XOFF point to 64 characters or less (in the receive input buffer).

2.2.2 Guidelines and Examples

The choice of XON and XOFF points is complicated because there are several competing objectives that can be optimized. XON and XOFF points should be chosen to provide a reasonable compromise between these objectives for the intended use of the device. For some devices it may be desirable to make the XON and XOFF points user configurable.

To increase the amount of response time available to accomodate end to end signaling delays (satellite relay of telephone signals can take hundreds of milliseconds for example), it is desirable to provide lots of receive buffer space after the first XOFF point.

To allow a sender to finish a printing task as early as possible, it is desirable to make the XON point high (closer to buffer full).

To reduce the amount of XON/XOFF traffic and/or the number of data transfers, it is desirable to have the XON and (first) XOFF point far apart.

To maximize throughput, it is desirable to balance the XON response time (before the receive input buffer empties) with the XOFF response time so the receiver does not sit idle waiting for the sender to respond to XON.

For interactive video terminals that provide 32 characters of input buffer space beyond the last XOFF point, the XON point will normally be at 32 characters, or at half the number of characters to the first XOFF point, whichever is less.

EXAMPLES

The VT100 provides a 64-character receive input buffer with the first XOFF point at 32 characters, no second XOFF point, and XON point at 16 characters.

The VT220 provides a 254-character receive input buffer with the first XOFF point selectable to 64 or 128 characters. The second XOFF point is 220 characters. The XON point is 32 characters.

The VT100 and VT220 are designed to provide 32 characters of input buffer space to respond to XOFF (from the XOFF point to buffer full on the VT100, and from the second XOFF point to buffer full on the VT220).

2.3 RECEIVE BUFFER SIZE

Terminals shall provide at least 64 characters of receive input buffer space, with at least 32 characters of input buffer space beyond each XOFF point supported.

Although existing Digital Terminals respond to XOFF within two character times, other receiving devices (including host computers) should provide at least 32 characters of input buffer space beyond the XOFF point to be symmetric with the VT100 and VT200 terminal families (not mandatory). This is desirable to support PCs and Workstations running terminal emulator software.

In all cases, the receive input buffer size and XOFF point must be sufficient to prevent buffer overflow under the intended operating conditions.

2.4 BUFFER OVERFLOW PREVENTION

In order to prevent buffer overflow, the sending device must respond to an XOFF within some maximum amount of time which depends on the size of the receiver's input buffer, its XOFF point, and the transmission rate.

2.4.1 Number of Characters to Buffer Overflow

When the sending and receiving transmission rate are the same, the maximum guaranteed number of characters before buffer overflow assuming immediate response is:

```
    OVFL = (MXBF - XOFF) - 3
```

Where:

```
    OVFL = the number of characters before overflow
    MXBF = the receive buffer size
    XOFF = the XOFF point
```

The constant '3' derives from the following possible character delays: (1) When the receive buffer reaches the XOFF point, the receiving device may be in the middle of sending a character and unable to send XOFF until the character finishes; (2) It takes one character time to transmit the XOFF; (3) Assuming the transmitting device can respond immediately to the XOFF, it must still finish the character it is currently sending (if any).

Situations that may reduce the number of characters before buffer overflow include:

1. Systems that support different transmit and receive speeds (the slower channel cannot send or receive the XOFF as fast

   ```
   OVFL = (MXBF-XOFF) - [3(RCDR/XMDR)] ).
   ```

2. Systems that utilize transmit output buffers and cannot insert XOFF into the output stream immediately.
3. Systems that employ "transmit rate limiting" to limit the number of characters per second below the maximum allowed by the baud rate.

DEVIATION NOTE

The number of characters before buffer overflow on the VT220, and VT300 family is calculated differently because received characters are only handled during V Blank time. The actual formula is:

```
OVFL = (MXBF-XOFF)-[3(RCDR/XMDR)]-(RCDR/600)
```

The last term takes into account the worst case for when the received character would get serviced.

The VT220 and VT300 series will not consistently transmit XOFF within five character times of reaching an XOFF point (but they still provide more than 32 characters of buffer space from when the first XOFF is sent). This delay until V Blank time should be discouraged in future devices.

2.4.2 Response Time to XOFF

The maximum response time available to the sending device to stop sending (in order to guarantee that the buffer will not overflow) is the time it takes to transmit the number of characters until buffer overflow (OVFL).

```
    MRST = OVFL x [(DATA + STOP + PRTY + 1)/XMDR]
```

where:

```
    MRST = maximum response time
    OVFL = the number of characters before overflow
    DATA = the number of data bits per character
    STOP = the number of stop bits per character
    PRTY = the number of parity bits per character
    '1'  = the start bit
    XMDR = the transmit data rate (bits per second)
```

It is recommended (but not mandatory) that the sending device stop transmitting immediately upon receipt of an XOFF (after the current character).

XON/XOFF flow control is intended for use over point to point full duplex links. The time available to respond to XOFF will be reduced by any end to end signaling delays.

2.4.3 Response Time Example

If the sending device is a host computer intended to work with a VT100 at 9600 bits per second, the maximum response time can be computed as follows:

```
OVFL = (MXBF - XOFF) - 3
     = (64   - 32)   - 3
     = 29 characters until overflow
```

Assuming 8-bit characters with no parity and one stop bit:

```
MRST = OVFL x [(DATA + STOP + PRTY + 1)/XMDR]
     = 29   x [(8    + 1    + 0    + 1)/9600]
     = 0.030 seconds
```

For this example, the sending device including transmission delays in either direction must respond to XOFF within 30 milliseconds to avoid buffer overflow.

2.5 INITIALIZATION

When a device first powers on, it has no way of knowing the XON/XOFF state of a communication link. Devices shall send a single XON at power-up when they are ready to receive data, and assume their transmitter is in the XON state.

Devices that can be locally controlled (that is, have some form of keyboard or local control panel) shall provide a means for the operator to re-initialize the XON/XOFF state. This "Clear Communications" function will include the following actions: (1) clear the device's transmit queue; (2) clear the XOFF state of the device's communication port; (3) transmit a single XON to the remote device.

GUIDELINE

The VT100 sends XON at power-up, and allows the XON/XOFF state to be re-initialized by entering and exiting Set-Up.

The VT220 sends XON at power-up. A "Clear Comm" function is provided in Set-Up to re-initialize the XON/XOFF state.

2.6 OTHER EVENTS THAT AFFECT XON/XOFF STATE

2.6.1 Special Characters

Some devices interpret other characters besides XON to mean "okay to resume transmission". These characters are not synonymous with XON and shall be treated as special conditions that re-initialize the XON/XOFF state. It is up to the device receiving data to decide what, if any, special characters will clear its XOFF state. A device sending data shall not assume any characters other than XON will clear the XOFF state of the receiving device.

GUIDELINE

Some operating systems have interpreted CTRL/Y and CTRL/C as events that re-initialize the XON/XOFF state. Upon receipt of CTRL/Y (when CTRL/Y handling is enabled), VMS clears the communication port's output queue, clears the XOFF state of the communication port, and transmits an XON to the terminal. Terminals should not assume, however, that sending CTRL/Y will clear the XOFF state of the remote device, and should not re-initialize their own XON/XOFF state upon sending CTRL/Y.

2.6.2 Local Events (Guidelines)

Some devices generate XON or XOFF flow control as a result of local events which affect the processing of incoming data.

The VT100 sends XOFF when entering Set-Up, and sends XON upon exit from Set-Up. The VT220 enters the hold screen state (if not already held) when entering Set-Up, and leaves the hold screen state if not previously held upon exiting Set-Up.

The LN03 sends XOFF when the paper cover is lifted and sends XON when the paper cover is replaced. It is suggested that printers send XOFF when they are unable to process incoming data (including going off-line), and send XON when they are again ready to process incoming data (including going on-line).

2.7 RESERVED CHARACTERS

DC1 (1/1) (XON) and DC3 (1/3) (XOFF) are to be used for synchronization in the manner described in this standard. DC2 (1/2) and DC4 (1/4) are reserved for future use, likely for synchronization. These characters should not be used to convey meaning to application software.

2.8 TERMINAL KEYBOARD SYNCHRONIZATION

When XON/XOFF flow control is enabled, terminals may be XOFF-ed to suspend transmission of characters to the host. Terminals will maintain a silo for keyboard output. In the event that the keyboard produces characters faster than they can be sent, the silo will buffer at least nine keystrokes. For the purpose of buffering, a compose sequence or function key counts as one keystroke. If the silo becomes full, keystrokes may be discarded. Terminals shall provide some indication that the silo is full and/or keystrokes are being discarded.

GUIDELINE

In the VT200 family, the Wait LED comes on when the keyboard silo is full, and the keyboard stops clicking (if keyclick was enabled) when keystrokes are being ignored.

2.9 TERMINAL SCREEN SYNCHRONIZATION (HOLD SCREEN)

When XON/XOFF flow control is enabled, terminals shall allow the data on the screen to be held for easy reading (stop scrolling) even though data is still being received from the host computer. The "Hold Screen" function is a toggle that switches the terminal screen between the HELD and NOT_HELD states. The Hold Screen function does not transmit XON or XOFF, but may cause the terminal's input buffer to fill when the screen is in the HELD state, and empty again when the screen is returned to the NOT_HELD state.

When XON/XOFF flow control is enabled, typing CTRL/S (XOFF) or CTRL/Q (XON) at the keyboard will not transmit codes to the host computer. Instead, these keystrokes will toggle the hold screen state between HELD and NOT_HELD respectively.

When XON/XOFF flow control is disabled, the Hold Screen function does not operate and typing CTRL/S (XOFF) or CTRL/Q (XON) at the keyboard will transmit the corresponding codes to the host computer.

2.10 EMERGENCY MESSAGES

At times, one device may need to send another a high-priority or emergency message. If the intended receiver has sent an XOFF however, it has indicated that it is not ready to receive more data. This may be because the receiver is literally unable to receive or process a message (a printing terminal with a blown fuse, for example), or it may just be that the operator has activated the Hold Screen function.

At the time of this update to the standard, there is no clear consensus on how to handle emergency messages.

DEVIATION NOTE

Some printers respond to device status inquiries immediately even when they are in the XOFF state (using the XOFF state as a control channel). This mechanism should be used only by explicit, device dependent agreement between the printer and supporting host. It is not part of the XON/XOFF protocol, and may not be supported in future devices.

2.11 IMPLIED XOFF RULE

Certain terminal functions during which the terminal is unable to respond to host data use an implied XOFF rule. The implied XOFF rule allows the host to suspend transmission until the terminal is again able to respond. When a host computer invokes one of these functions, it is to enter the XOFF state as if an XOFF had been received from the terminal (implied XOFF). Upon completing the requested function, the terminal must send an XON to re-enable host transmission.

Currently, only RIS (Reset to Initial State) and DECTST (DEC Test) use the implied XOFF rule. These functions are intended for diagnostics and shall not be used by conforming application software. Under normal operation, terminal devices should not stop monitoring the communication line, or should send XOFF before going "off line".

3 BREAK

Break is an out of band signal frequently used to reset the communications environment or data interchange context over serial asynchronous lines. The Break condition is defined as a continuous space (transmission line held in its zero state) for longer than one character time. See DEC STD 52 for additional information on physical generation of the break signal. Although there is no standard use for Break, Digital terminals allow the Break signal to be generated under user control.

The remainder of this section describes how the Break signal is transmitted, when it may be transmitted, and operation of the break key.

3.1 THE BREAK SIGNAL

Although Break is defined as a continuous space exceeding one character time, the duration of the Break signal generated by Digital terminals has been standardized for reliability. The Break signal will hold the transmission line to its zero state for 275 milliseconds (plus or minus 25 ms).

3.1.1 Long Break Disconnect

Some modems use a longer Break of 3.5 seconds to signal a remote data set to disconnect from the communications line. When used, this signal is generated by the modem. Terminals indicate disconnect to a modem using the DTR modem control signal. There is no known reason for a terminal to generate the 3.5 second long Break.

GUIDELINE

The VT220 and newer terminals do not generate the long break signal. On the VT100, pressing SHIFT/BREAK would generate a long break in addition to dropping DTR.

3.2 WHEN BREAK MAY BE TRANSMITTED

A Break signal may be transmitted by terminals only upon activation of the break key. Break shall never be transmitted during power-up, power-down, self-test, or terminal reset operations.

Previous terminals (VT100, VT220) have transmitted Break during power-up, and self-test. This use of Break should be eliminated for the following reasons:

- It does not conform to DEC STD 052-1 which requires TXD (transmit data) be held in the mark state during power-up.
- Break is used by some Digital systems to halt the console CPU. Transmitting Break at power-up is inappropriate for these systems.
- Sending Break during self-test precludes the use of remote diagnostics. If a host requests a terminal self-test, the resulting Break may cause a disconnect.

3.3 OPERATION OF THE BREAK KEY

When the break key is activated, special provision shall be made to transmit a Break signal immediately regardless of keyboard locking (KAM), XON/XOFF flow control, or the state of the keyboard input silo. If a character is currently being transmitted, the Break signal will begin as soon as the stop bit of the current character has completed to avoid loss of data. Activating the break key does not clear the keyboard input silo, reset KAM, or change the XON/XOFF flow control state.

3.4 RECEIPT OF BREAK

Terminals shall detect break explicitly and do nothing at all when break is received at the host communication port.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00052-00	*DEC STD 052-0 Operational Requirements for Serial Terminals and Computer Interfaces Operating as DTEs Connected to EIA RS-232-C or CCITT V.28 Modems*
EL-00052-01	*DEC STD 052-1 Operational Requirements for Serial Data Terminal Equipment and Serial System Interfaces Operating as DTEs Connected to EIA RS-232-C or CCITT V.28 Point-To-Point Modems or Data Service Units*

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